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Takahashi et al.

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(54) **DISPLAY DEVICE, AND BRIGHTNESS CONTROL SIGNAL GENERATION METHOD**

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G09G 3/34 (2006.01)

(52) **U.S. Cl.**
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(Continued)

(58) **Field of Classification Search**
CPC G09G 5/00; G09G 3/36; G09G 3/34; G06F 3/038
USPC 345/102, 690, 89, 90, 92, 94, 98, 99, 345/100, 208
See application file for complete search history.

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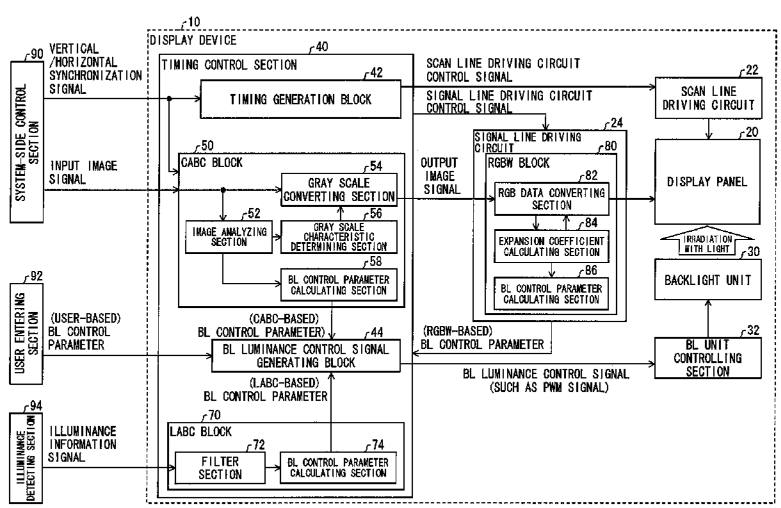
(57) **ABSTRACT**

Provided is a display device capable of properly controlling a luminance of a backlight on the basis of a plurality of factors. The display device is a display device (**10**) which includes a BL luminance control signal generating block (**44**) for generating a BL luminance control signal for controlling a luminance of a backlight unit (**30**). The BL luminance control signal generating block (**44**) (i) receives a plurality of BL luminance parameters regarding the luminance of the backlight unit (**30**), (ii) carries out a calculation process with respect to the plurality of BL luminance parameters and (iii) generates the BL luminance control signal on the basis of a result of the calculation process.

11 Claims, 11 Drawing Sheets



(52) **U.S. Cl.**
CPC . *G09G 2340/0428* (2013.01); *G09G 2360/144* (2013.01); *G09G 2360/16* (2013.01)

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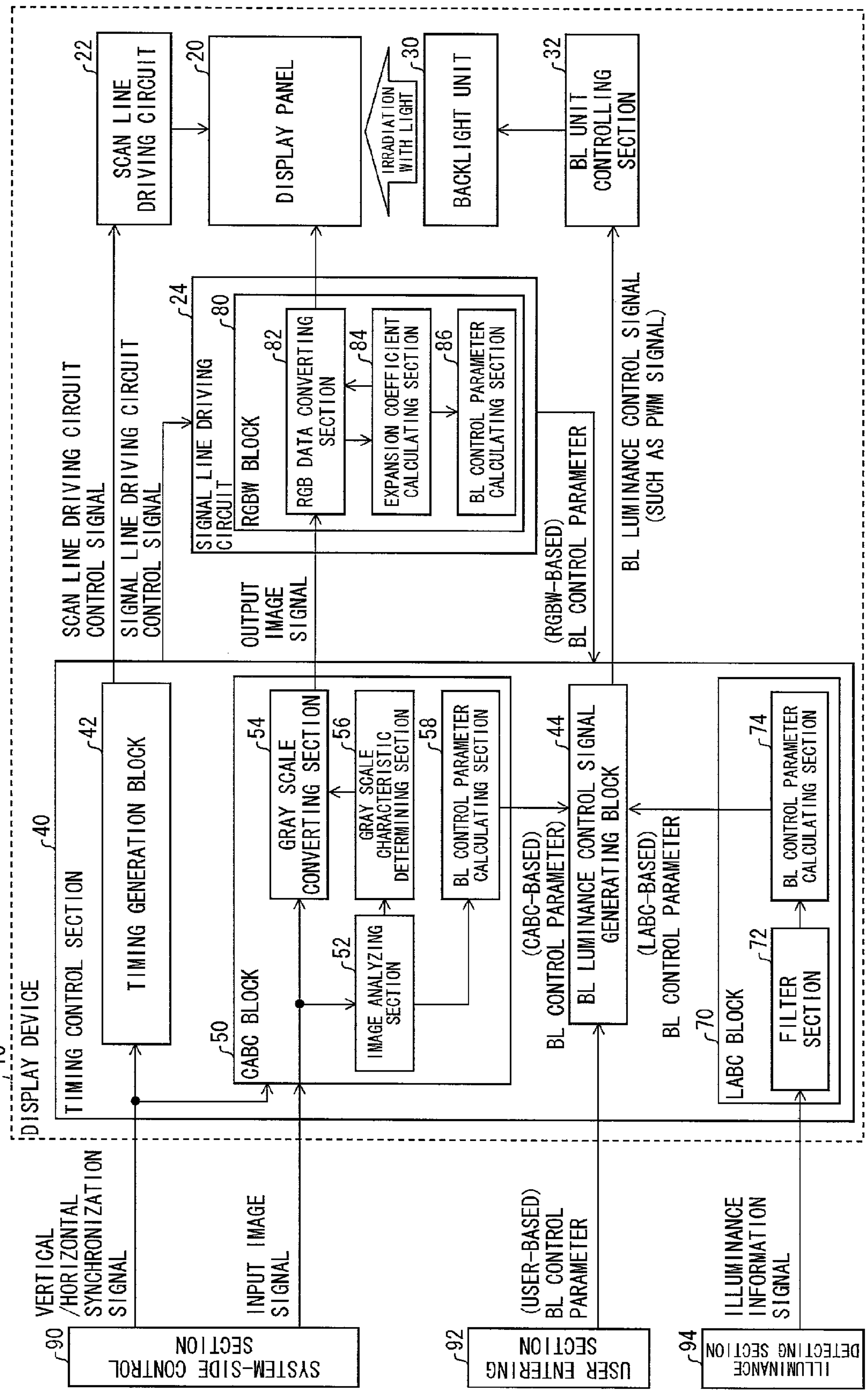
FIG. 1



10 DISPLAY DEVICE
22 SCAN LINE DRIVING CIRCUIT
20 DISPLAY PANEL
IRRADIATION WITH LIGHT
30 BACKLIGHT UNIT
32 BL UNIT CONTROLLING SECTION
24 SIGNAL LINE DRIVING CIRCUIT
80 RGBW BLOCK
82 RGB DATA CONVERTING SECTION
84 EXPANSION COEFFICIENT CALCULATING SECTION
86 BL CONTROL PARAMETER CALCULATING SECTION
SCAN LINE DRIVING CIRCUIT CONTROL SIGNAL
SIGNAL LINE DRIVING CIRCUIT CONTROL SIGNAL
OUTPUT IMAGE SIGNAL
(RGBW-BASED) BL CONTROL PARAMETER
BL LUMINANCE CONTROL SIGNAL (SUCH AS PWM SIGNAL)
40 TIMING CONTROL SECTION
42 TIMING GENERATION BLOCK
50 CABC BLOCK
52 IMAGE ANALYZING SECTION
54 GRAY SCALE CONVERTING SECTION
56 GRAY SCALE CHARACTERISTIC DETERMINING SECTION
58 BL CONTROL PARAMETER CALCULATING SECTION
(CABC-BASED) BL CONTROL PARAMETER
44 BL LUMINANCE CONTROL SIGNAL GENERATING BLOCK
(LABC-BASED) BL CONTROL PARAMETER
70 LABC BLOCK
72 FILTER SECTION
74 BL CONTROL PARAMETER CALCULATING SECTION
VERTICAL /HORIZONTAL SYNCHRONIZATION SIGNAL
INPUT IMAGE SIGNAL
(USER-BASED) BL CONTROL PARAMETER
ILLUMINANCE INFORMATION SIGNAL
90 SYSTEM-SIDE CONTROL SECTION
92 USER ENTERING SECTION
94 ILLUMINANCE DETECTING SECTION

FIG. 2

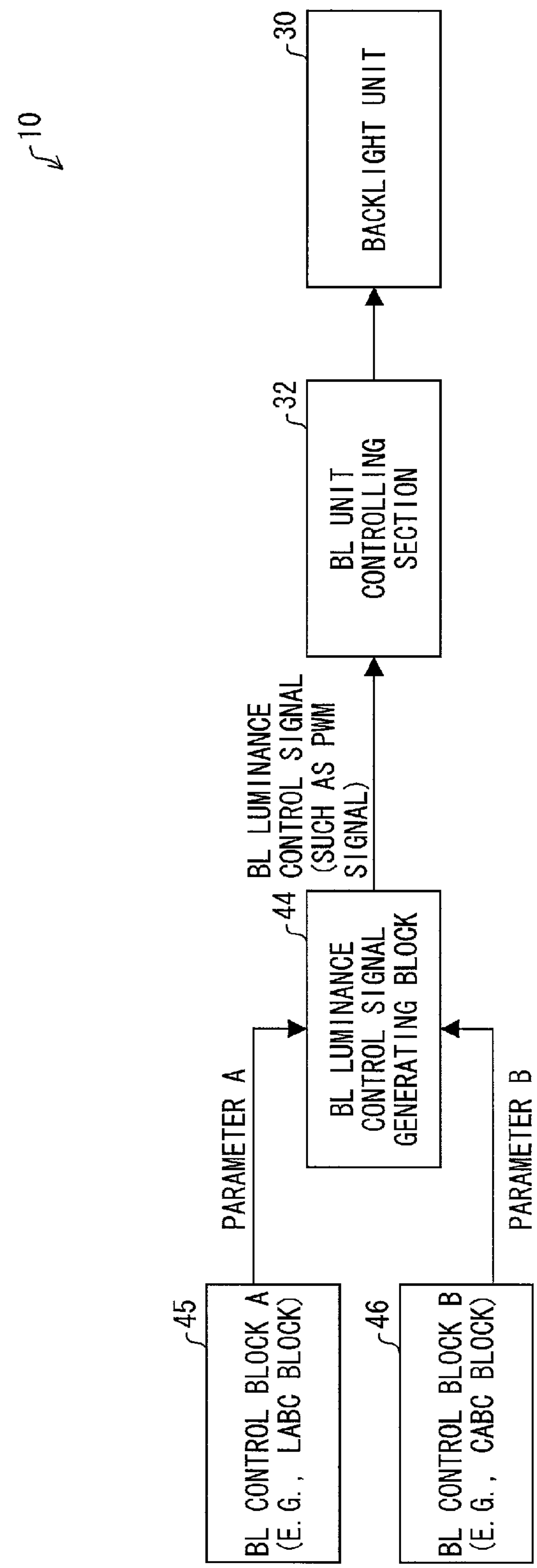

10
BACKLIGHT UNIT
30
BL UNIT CONTROLLING SECTION
32
BL LUMINANCE CONTROL SIGNAL (SUCH AS PWM SIGNAL)
BL LUMINANCE CONTROL SIGNAL GENERATING BLOCK
44
PARAMETER A
PARAMETER B
BL CONTROL BLOCK A (E.G., LABC BLOCK)
45
BL CONTROL BLOCK B (E.G., CABC BLOCK)
46

FIG. 3

CALCULATION EXAMPLE 1: WHERE PARAMETER IS DUTY RATIO

PARAMETER A (DUTY RATIO) = 70/100

PARAMETER B (DUTY RATIO) = 30/100

DUTY RATIO OF PWM SIGNAL TO BE OUTPUTTED = 70×30/100×100 = 21/100

DUTY RATIO OF
PWM SIGNAL TO BE
OUTPUTTED: 21%

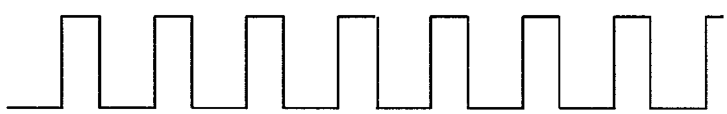


FIG. 4

CALCULATION EXAMPLE 2: WHERE PARAMETER IS LUMINANCE LEVEL

PARAMETER A (LUMINANCE LEVEL) = 12/16

PARAMETER B (LUMINANCE LEVEL) = 4/8

LUMINANCE LEVEL FOR GENERATION OF PWM SIGNAL = 12×4/16×8 = 6/16

OUTPUT OF PWM SIGNAL CORRESPONDING TO LUMINANCE LEVEL (55%)

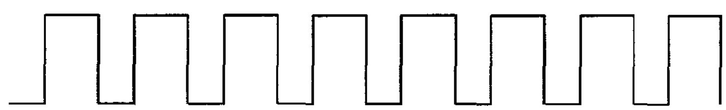
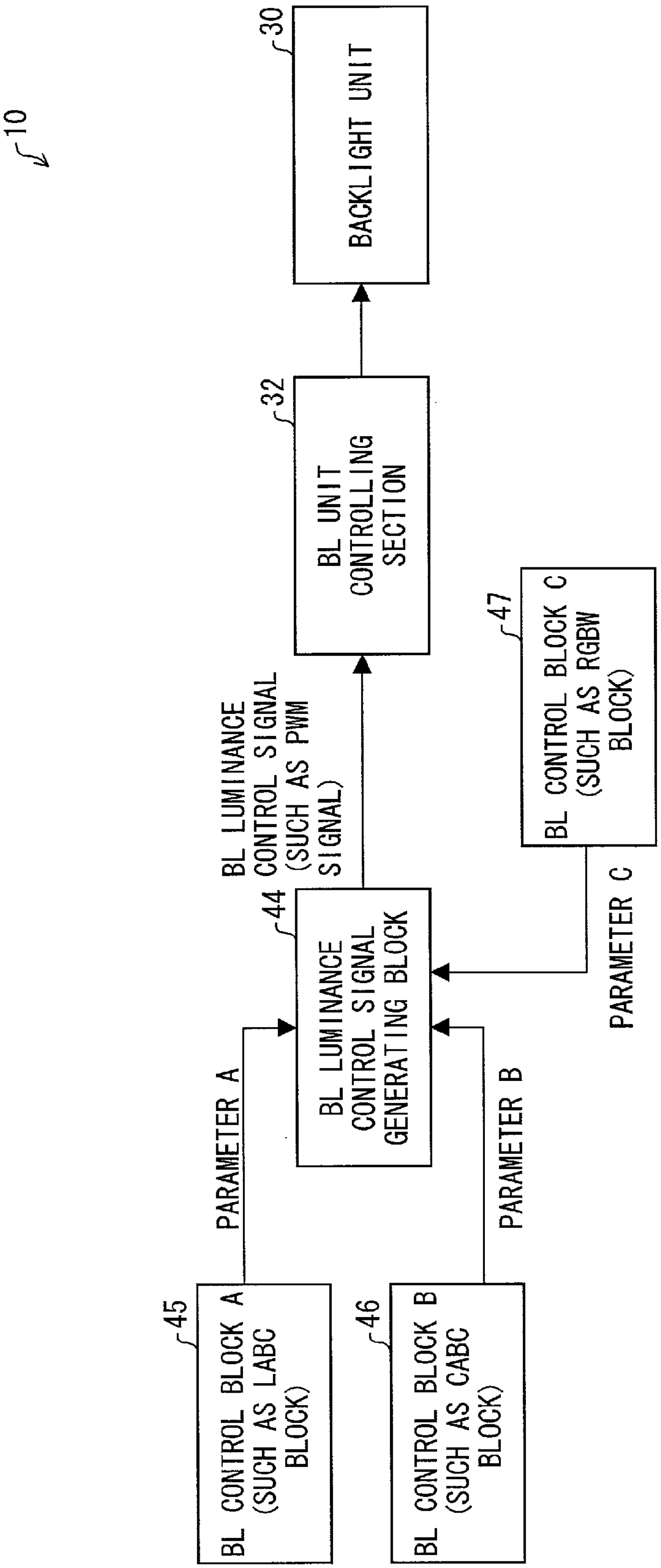


FIG. 5

TABLE IN WHICH LUMINANCE LEVEL IS CORRELATED WITH DUTY RATIO

LUMINANCE LEVEL	DUTY RATIO
1	10
2	20
3	25
–	–
6	55
–	–
16	100


10
BACKLIGHT UNIT
30
BL UNIT CONTROLLING SECTION
32
BL LUMINANCE CONTROL SIGNAL (SUCH AS PWM SIGNAL)
BL LUMINANCE CONTROL SIGNAL GENERATING BLOCK
44
BL CONTROL BLOCK C (SUCH AS RGBW BLOCK)
47
PARAMETER C
PARAMETER A
PARAMETER B
BL CONTROL BLOCK A (SUCH AS LABC BLOCK)
45
BL CONTROL BLOCK B (SUCH AS CABC BLOCK)
46

F I G. 6

FIG. 7

CALCULATION EXAMPLE 3: WHERE PARAMETER IS DUTY RATIO

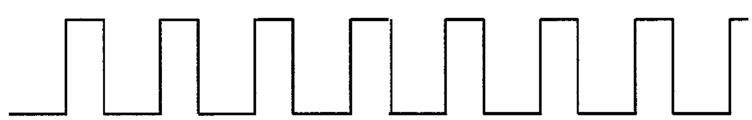
PARAMETER A (DUTY RATIO) = 80/100

PARAMETER B (DUTY RATIO) = 60/100

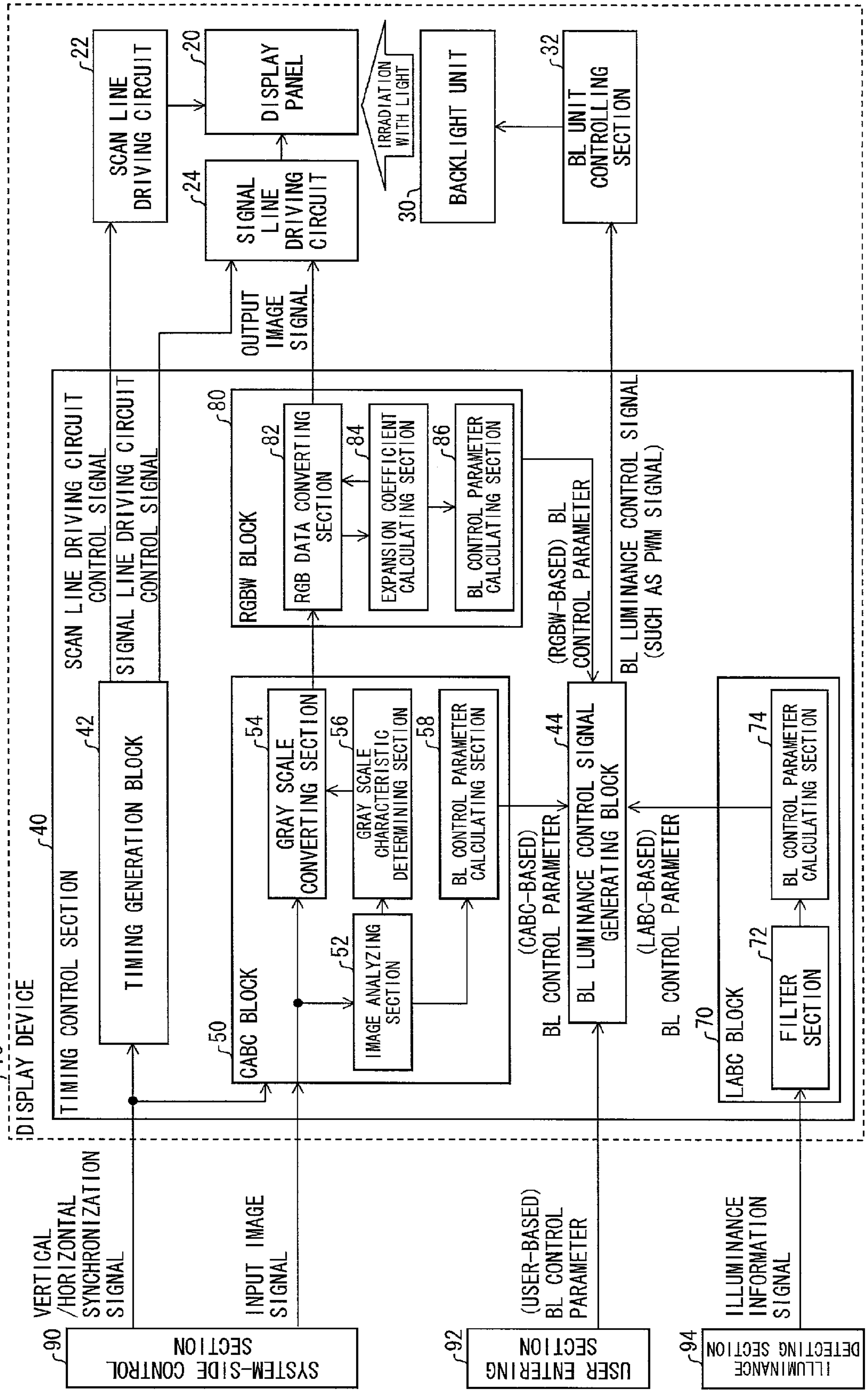
PARAMETER C (DUTY RATIO) = 50/100

DUTY RATIO OF PWM SIGNAL TO BE OUTPUTTED $= 80 \times 60 \times 50/100 \times 100 \times 100$
$= 24/100$

DUTY RATIO OF PWM SIGNAL TO BE OUTPUTTED: 24%



F I G . 8


10
DISPLAY DEVICE
22
SCAN LINE DRIVING CIRCUIT
20
DISPLAY PANEL
24
SIGNAL LINE DRIVING CIRCUIT
IRRADIATION WITH LIGHT
30
BACKLIGHT UNIT
32
BL UNIT CONTROLLING SECTION
OUTPUT IMAGE SIGNAL
40
TIMING CONTROL SECTION
42
TIMING GENERATION BLOCK
SCAN LINE DRIVING CIRCUIT CONTROL SIGNAL
SIGNAL LINE DRIVING CIRCUIT CONTROL SIGNAL
80
RGBW BLOCK
82
RGB DATA CONVERTING SECTION
84
EXPANSION COEFFICIENT CALCULATING SECTION
86
BL CONTROL PARAMETER CALCULATING SECTION
(RGBW-BASED) BL CONTROL PARAMETER
BL LUMINANCE CONTROL SIGNAL (SUCH AS PWM SIGNAL)
50
CABC BLOCK
52
IMAGE ANALYZING SECTION
54
GRAY SCALE CONVERTING SECTION
56
GRAY SCALE CHARACTERISTIC DETERMINING SECTION
58
BL CONTROL PARAMETER CALCULATING SECTION
(CABC-BASED) BL CONTROL PARAMETER
44
BL LUMINANCE CONTROL SIGNAL GENERATING BLOCK
(LABC-BASED) BL CONTROL PARAMETER
70
LABC BLOCK
72
FILTER SECTION
74
BL CONTROL PARAMETER CALCULATING SECTION
VERTICAL /HORIZONTAL SYNCHRONIZATION SIGNAL
INPUT IMAGE SIGNAL
(USER-BASED) BL CONTROL PARAMETER
ILLUMINANCE INFORMATION SIGNAL
90
SYSTEM-SIDE CONTROL SECTION
92
USER ENTERING SECTION
94
ILLUMINANCE DETECTING SECTION

F I G. 9

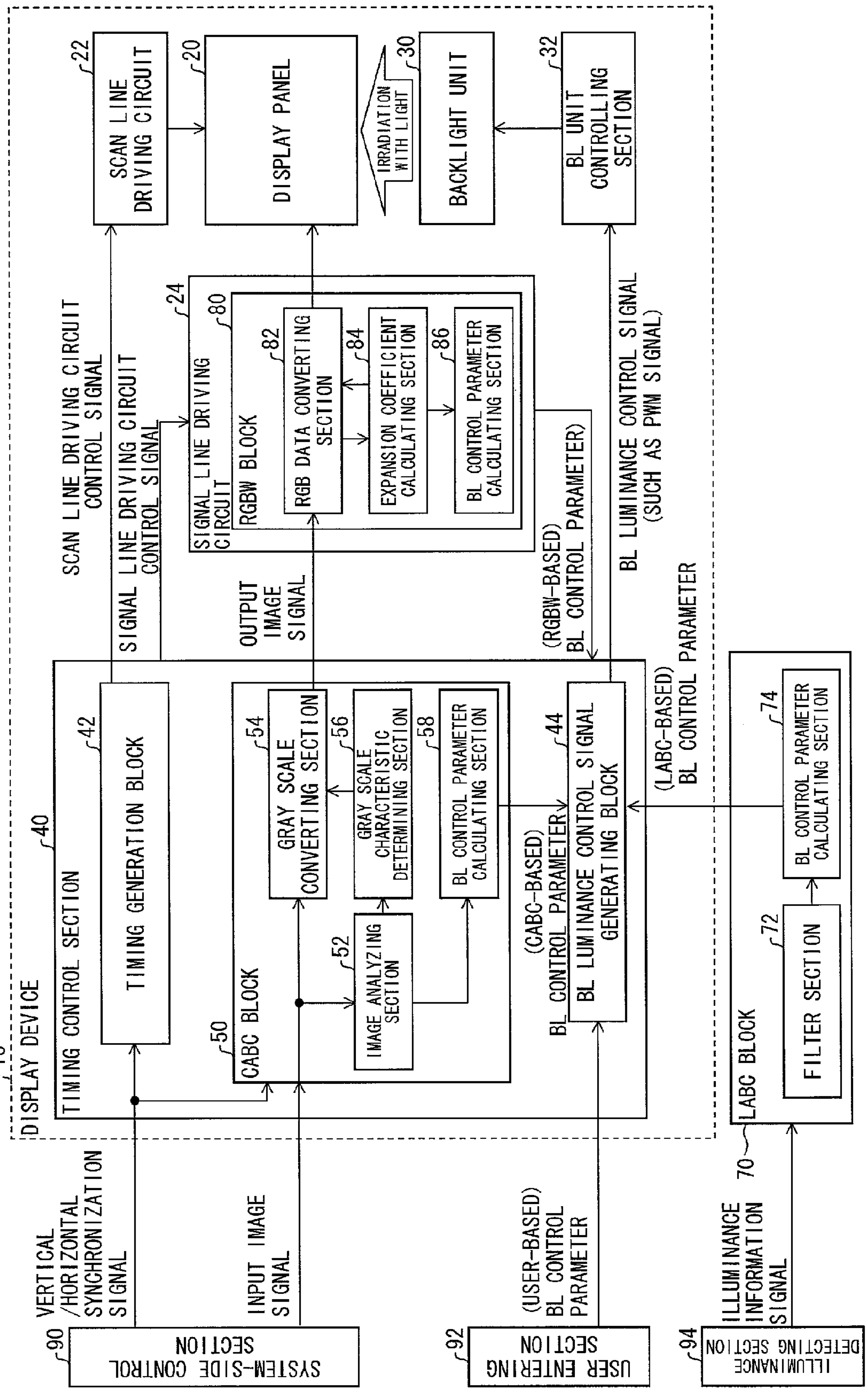

10 DISPLAY DEVICE
40 TIMING CONTROL SECTION
42 TIMING GENERATION BLOCK
50 CABC BLOCK
52 IMAGE ANALYZING SECTION
54 GRAY SCALE CONVERTING SECTION
56 GRAY SCALE CHARACTERISTIC DETERMINING SECTION
58 BL CONTROL PARAMETER CALCULATING SECTION
44 BL LUMINANCE CONTROL SIGNAL GENERATING BLOCK
(CABC-BASED) BL CONTROL PARAMETER
SCAN LINE DRIVING CIRCUIT CONTROL SIGNAL
SIGNAL LINE DRIVING CIRCUIT CONTROL SIGNAL
OUTPUT IMAGE SIGNAL
(RGBW-BASED) BL CONTROL PARAMETER
BL LUMINANCE CONTROL SIGNAL (SUCH AS PWM SIGNAL)
(LABC-BASED) BL CONTROL PARAMETER
24 SIGNAL LINE DRIVING CIRCUIT
80 RGBW BLOCK
82 RGB DATA CONVERTING SECTION
84 EXPANSION COEFFICIENT CALCULATING SECTION
86 BL CONTROL PARAMETER CALCULATING SECTION
22 SCAN LINE DRIVING CIRCUIT
20 DISPLAY PANEL
IRRADIATION WITH LIGHT
30 BACKLIGHT UNIT
32 BL UNIT CONTROLLING SECTION
70 LABC BLOCK
72 FILTER SECTION
74 BL CONTROL PARAMETER CALCULATING SECTION
VERTICAL /HORIZONTAL SYNCHRONIZATION SIGNAL
INPUT IMAGE SIGNAL
(USER-BASED) BL CONTROL PARAMETER
ILLUMINANCE INFORMATION SIGNAL
90 SYSTEM-SIDE CONTROL SECTION
92 USER ENTERING SECTION
94 ILLUMINANCE DETECTING SECTION

FIG. 10

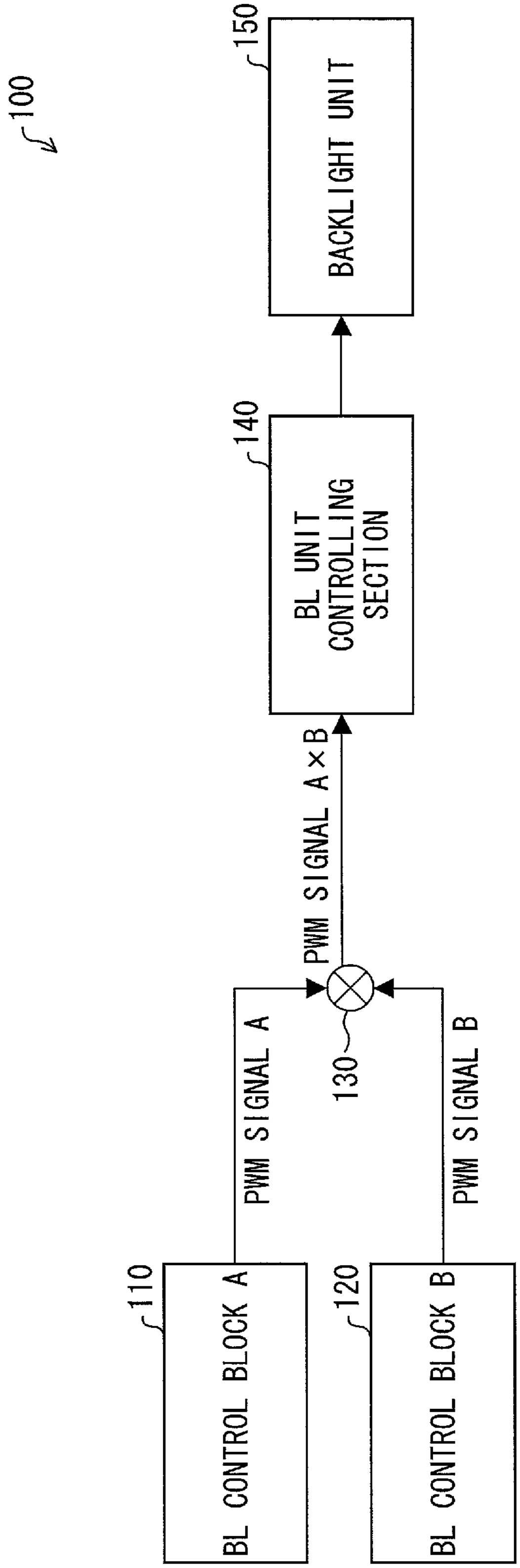
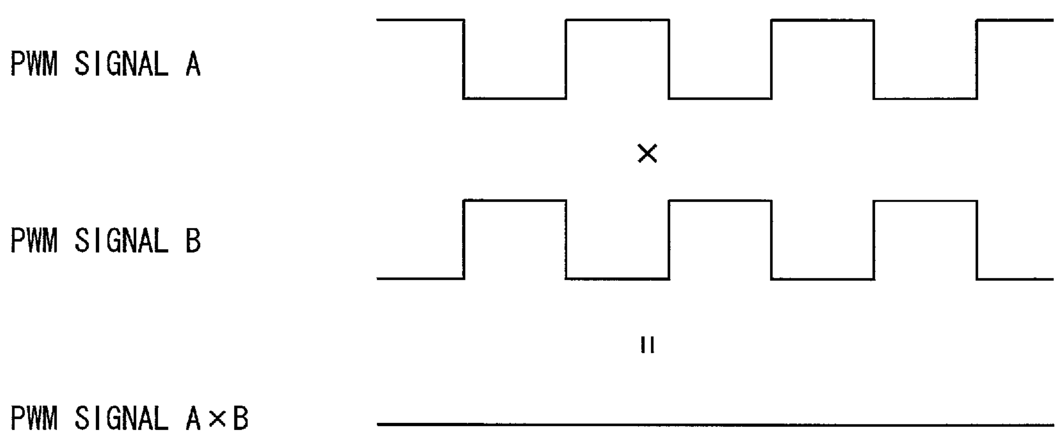

100
150
BACKLIGHT UNIT
140
BL UNIT CONTROLLING SECTION
PWM SIGNAL A×B
PWM SIGNAL A
130
PWM SIGNAL B
110
BL CONTROL BLOCK A
120
BL CONTROL BLOCK B

FIG. 11



DISPLAY DEVICE, AND BRIGHTNESS CONTROL SIGNAL GENERATION METHOD

TECHNICAL FIELD

The present invention relates to a display device, particularly, control of a luminance of a backlight.

BACKGROUND ART

In order to, for example, improve display quality and reduce power consumption, a luminance of a backlight has been controlled in a display device.

Specifically, there have proposed techniques such as (i) a first technique of controlling the luminance in accordance with brightness of an environment and (ii) a second technique of controlling the luminance in accordance with an image to be displayed.

Examples of the first technique include LABC (Light Adaptive Backlight Control). Examples of the second technique include CABC (Content Adaptive Backlight Control).

LABC controls a luminance of a backlight in accordance with an illuminance on the periphery of a display device (see Patent Literature 1 below). According to a technique such as a technique described in Patent Literature 1, the backlight is controlled to be turned on or off, in accordance with an illuminance level detected by an illuminance sensor.

CABC controls a luminance of a backlight in accordance with, for example, an image to be displayed (see Patent Literature 2 below).

CITATION LIST

Patent Literatures

Patent Literature 1

Japanese Patent Application Publication, Tokuikai, No. 2001-265294 A

Patent Literature 2

U.S. Pat. No. 6,816,141, specification

SUMMARY OF INVENTION

Technical Problem

The above-described backlight luminance controls will cause a problem in a case where there exist a plurality of luminance control factors, that is, a plurality of matters which should be taken into consideration so that an optimal luminance is determined.

(Schematic Configuration)

The following description will discuss luminance control with reference to FIG. **10**. FIG. **10** is a block diagram schematically illustrating the luminance control according to a conventional technique.

As illustrated in FIG. **10**, a display device **10** includes (i) a BL (backlight; hereinafter same as above) control block A **110**, (ii) a BL control block B **120**, (iii) a control signal synthesizing section **130**, (iv) a BL unit controlling section **140** and (v) a backlight unit **150**.

The BL control block A **110** and the BL control block B **120** are connected to the control signal synthesizing section **130**.

The BL control block A **110** supplies a PWM (Pulse Width Modulation) signal A to the control signal synthesizing section **130**. The BL control block B **120** supplies a PWM signal B to the control signal synthesizing section **130**.

The control signal synthesizing section **130** superimposes the PWM signal A and the PWM signal B on each other so as to synthesize a PWM signal A×B.

The control signal synthesizing section **130** then supplies the PWM signal A×B to the BL unit controlling section **140** that is connected to the control signal synthesizing section **130**.

The BL unit controlling section **140** controls, in accordance with the PWM signal A×B, a luminance of the backlight unit **150** that is connected to the BL unit controlling section **140**.

(Synthesis of Signal)

The following description will discuss, with reference to FIG. **11**, how the control signal synthesizing section **130** synthesizes the PWM signal A×B from the PWM signal A and the PWM signal B. FIG. **11** is a waveform diagram schematically illustrating superimposition of PWM signals according a conventional technique.

As illustrated in FIG. **11**, in a case where two different PWM signals (a PWM signal A and a PWM signal B) are superimposed on each other, a defect, such as turn-off of the backlight unit **150**, will be caused due to loss of duty.

Specifically, for example, in a case where first and second PWM signals, each having a duty ratio of 50%, are superimposed on each other, a high (High) part of the first PWM signal and a low (Low) part of the second PWM signal will be superimposed on each other depending on frequencies or phases of the first and second PWM signals. This possibly causes loss of duty. Such loss of duty causes the backlight unit **150** to be turned off.

FIG. **11** illustrates (i) the PWM signal A, (ii) the PWM signal B whose phase is shifted by a half cycle from that of the PWM signal A and (iii) a PWM signal A×B (duty: 0%) in which the PWM signal A and the PWM signal B are superimposed on each other.

The present invention was made in order to solve the problem, and an object of the present invention is to provide a display device capable of properly controlling a luminance of a backlight on the basis of a plurality of factors.

Solution to Problem

In order to attain the object, a display device of the present invention is configured to be a display device which includes a signal generating section for generating a luminance control signal for controlling a luminance of a backlight, the signal generating section (i) receiving a plurality of parameters regarding the luminance of the backlight, (ii) carrying out a calculation process with respect to the plurality of parameters, and (iii) generating the luminance control signal on the basis of a result of the calculation process.

In order to attain the object, a method, of the present invention, of generating a luminance control signal is arranged to be a method of generating a luminance control signal for controlling a luminance of a backlight, the method including the steps of: (i) carrying out a calculation process in advance with respect to a plurality of parameters regarding the luminance; and (ii) generating the luminance control signal on the basis of a result of the calculation process.

According the configuration or the arrangement, a plurality of luminance control signals, such as a plurality of PWM signals, are not superimposed on each other, but (i) a plurality of parameters regarding the luminance of the backlight are subjected to a calculation process, and then (ii) a luminance control signal is generated on the basis of a result of the calculation process.

It is therefore unlikely to cause a defect, such as turn-off of the backlight due to change of a luminance control signal to an undesired signal, e.g., loss of duty of a PWM signal.

It is therefore possible to properly control the luminance of the backlight on the basis of a plurality of factors.

Advantageous Effects of Invention

A display device of the present invention is configured so that a signal generating section (i) receives a plurality of parameters regarding a luminance of a backlight, (ii) carries out a calculation process with respect to the plurality of parameters and (iii) generates a luminance control signal on the basis of a result of the calculation process.

A method, of the present invention, of generating a luminance control signal includes the steps of: (i) carrying out a calculation process in advance with respect to a plurality of parameters regarding the luminance; and (ii) generating the luminance control signal on the basis of a result of the calculation process.

It is therefore possible to bring about an effect of properly controlling the luminance of the backlight on the basis of a plurality of factors.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram schematically illustrating a configuration of a display device in accordance with an embodiment of the present invention.

FIG. **2** is a block diagram schematically illustrating luminance control in accordance with an embodiment of the present invention.

FIG. **3** is a view illustrating an example of how to calculate parameters in accordance with an embodiment of the present invention.

FIG. **4** is a view illustrating another example of how to calculate parameters in accordance with an embodiment of the present invention.

FIG. **5** illustrates a correlation table, in accordance with an embodiment of the present invention, which shows how a luminance level and a duty ratio are correlated with each other.

FIG. **6** is a block diagram schematically illustrating another luminance control in accordance with an embodiment of the present invention.

FIG. **7** is a view illustrating yet another example of how to calculate parameters in accordance with an embodiment of the present invention.

FIG. **8** is a block diagram schematically illustrating how a display device in accordance with another embodiment of the present invention is configured.

FIG. **9** is a block diagram schematically illustrating how a display device in accordance with yet another embodiment of the present invention is configured.

FIG. **10** is a block diagram schematically illustrating luminance control according a conventional technique.

FIG. **11** is a waveform diagram schematically illustrating superimposition of PWM signals according to a conventional technique.

DESCRIPTION OF EMBODIMENTS

The following description will discuss an embodiment of the present invention.

Embodiment 1

Embodiment 1 of the present invention will be described below with reference to FIGS. **1** through **7**.

(Schematic Configuration)

A configuration of a display device **10** of Embodiment 1 will be schematically described below with reference to FIG. **1**. FIG. **1** is a block diagram schematically illustrating the configuration of the display device **10**.

The display device **10** mainly includes (i) a timing control section **40**, (ii) a scan line driving circuit **22**, (iii) a signal line driving circuit **24**, (iv) a display panel **20**, (v) a backlight unit **30** and (vi) a BL (backlight) unit controlling section **32** (see FIG. **1**).

Each of the scan line driving circuit **22** and the signal line driving circuit **24** supplies, to the display panel **20**, signals for image display.

The backlight unit (backlight) **30** backlights the display panel **20**. The BL unit controlling section **32** controls a luminance and the like of the backlight unit **30**.

(Timing Control Section)

The timing control section **40** will be described below.

The timing control section **40** of Embodiment 1 mainly includes (i) a timing generation block **42**, (ii) a CABC (Content Adaptive Backlight Control) block **50**, (iii) a BL luminance control signal generating block **44** serving as a signal generating section and (iv) an LABC (Light Adaptive Backlight Control) block **70**.

(Timing Generation Block)

The timing generation block **42** generates a scan line driving circuit control signal and a signal line driving circuit control signal in response to supplied vertical/horizontal synchronization signals.

Specifically, the timing generation block **42** is connected to a system-side control section **90** so as to receive the vertical/horizontal synchronization signals from the system-side control section **90**.

The timing generation block **42** (i) generates a scan line driving circuit control signal and a signal line driving circuit control signal in response to the vertical/horizontal synchronization signals and (ii) supplies the scan line driving circuit control signal and the signal line driving circuit control signal to the scan line driving circuit **22** and the signal line driving circuit **24**, respectively, which are connected to the timing generation block **42**.

(CABC Block)

The CABC (Content Adaptive Backlight Control) block **50** (i) carries out a gray scale conversion with respect to an input image signal in accordance with a luminance of an inputted image etc. and (ii) supplies, as an output image signal, the input image signal to the signal line driving circuit **24**. The CABC block **50** also calculates, on the basis of the input image signal, a parameter which is used to control the luminance of the backlight unit **30**.

The CABC block **50** includes (i) an image analyzing section **52**, (ii) a gray scale converting section **54**, (iii) a gray scale characteristic determining section **56**, and (iv) a BL control parameter calculating section **58**.

The CABC block **50** receives, from the system-side control section **90**, vertical/horizontal synchronization signals and an input image signal. Specifically, the input image signal is supplied to the gray scale converting section **54** and the image analyzing section **52**.

Note here that, in a case where an image is displayed without an input image signal being subjected to any special process, the input image signal is (i) supplied to the gray scale converting section **54**, (ii), if necessary, subjected to gray scale conversion, and then (iii) supplied, as an output image signal, to the signal line driving circuit **24**.

On the other hand, in a case where an output image signal is generated after an input image signal is subjected to an image process such as shift of a gray scale value, (i) the input image signal is supplied to the image analyzing section **52**, (ii) the gray scale characteristic determining section **56** determines, on the basis of an image analysis result obtained by the image analyzing section **52**, what image process should be carried out on the input image signal (iii) the gray scale converting section **54** generates the output image signal based on a determination made by the gray scale characteristic determining section **56**, and then (iv) the gray scale converting section **54** supplies the output image signal to the signal line driving circuit **24**.

Note that the CABC block **50** determines a suitable luminance of the backlight unit **30** on the basis of the image analysis result. Specifically, the image analyzing section **52** supplies the image analysis result to the BL control parameter calculating section **58**. Based on the image analysis result, the BL control parameter calculating section **58** (i) calculates a BL control parameter which is used to control the luminance of the backlight unit **30** and then (ii) supplies the BL control parameter to the BL luminance control signal generating block **44**.

The following description will discuss examples of how (i) the CABC block **50** makes an image analysis and (ii) the luminance of the backlight unit **30** is controlled.

According to an example, in a case of a bright image, the luminance of the backlight unit **30** is increased so that the bright image is displayed more vividly, whereas, in a case of an image which verges on black, the luminance of the backlight unit **30** is decreased so that a black color looks like more black. This causes an increase in contrast.

According to another example, in a case of a darkish input image, (i) a gray scale value of the darkish input image is shifted to become higher and (ii) the luminance of the backlight unit **30** is shifted to become lower.

This allows an image having a desired brightness to be displayed, and also allows power consumption to be reduced.

(LABC Block)

The LABC (Light Adaptive Backlight Control) block **70** will be described below. The LABC block **70** determines a suitable luminance of the backlight unit **30** in accordance with an environmental illuminance of the display device **10**, for example, a brightness on the periphery of the display device **10**.

The LABC block **70** includes a filter section **72** and a BL control parameter calculating section **74**. The filter section **72** is connected to an illuminance detecting section **94**.

The illuminance detecting section **94** (i) measures the brightness on the periphery of the display device **10** and (ii) supplies, as an illuminance information signal, the brightness thus measured to the filter section **72**.

The filter section **72** converts the illuminance information signal into a more stable illuminance information signal by eliminating noise components from the illuminance information signal.

The BL control parameter calculating section **74** (i) determines a suitable luminance of the backlight unit **30** on the basis of the illuminance information signal which has been supplied from the filter section **72** and (ii) calculates a BL control parameter and then supplies the BL control parameter to the BL luminance control signal generating block **44**.

Note that a location where the illuminance detecting section **94** is provided is not limited to a specific location. For example, the illuminance detecting section **94** can be provided in the display device **10** or can be provided independently of the display device **10**.

The following description will discuss examples of how the luminance of the backlight unit **30** is controlled in the LABC block **70**.

According to an example, in a case where the environmental illuminance of the display device **10** is high, the luminance of the backlight unit **30** is increased so that a display quality is prevented from being deteriorated because of the fact that environmental light on the display panel **20** gets into a viewer's eye.

According to another example, in a case where the environmental illuminance of the display device **10** is low, the luminance of the backlight unit **30** is decreased so that too dazzling display is prevented.

(RGBW Block)

An RGBW block **80** will be described below. The RGBW block **80** (i) converts an RGB (Red, Green, and Blue) output image signal into an RGBW (Red, Green, Blue, and White) image signal and (ii) calculates a suitable luminance of the backlight unit **30** on the basis of luminances of pixels corresponding to W.

A location where the RGBW block **80** is provided is not limited to a specific location. According to Embodiment 1, the RGBW block **80** is provided in the signal line driving circuit **24**.

The RGBW block **80** includes an RGB data converting section **82**, an expansion coefficient calculating section **84**, and a BL control parameter calculating section **86**.

The RGB data converting section **82** (i) receives an RGB output image signal from the gray scale converting section **54** (as early described) and (ii) converts the RGB output image signal into an RGBW image signal. During the converting, the expansion coefficient calculating section **84**, which is connected to the RGB data converting section **82**, calculates a luminance of a pixel corresponding to W.

The RGBW block **80** then supplies the RGBW image signal to the display panel **20**.

The expansion coefficient calculating section **84** supplies, to the BL control parameter calculating section **86**, information on the luminance of the pixel corresponding to W. The BL control parameter calculating section **86** (i) calculates a BL control parameter on the basis of the information and (ii) supplies the BL control parameter to the BL luminance control signal generating block **44**.

The following description will discuss an example of how the luminance of the backlight unit **30** is controlled in the RGBW block **80**. According to an example, in a case where the luminance of the pixel corresponding to W is high, the luminance of the backlight unit **30** is decreased so that power consumption is reduced.

Note that a pixel color to be added by converting an RGB image signal into a four-color image signal is not limited to W, and can therefore be any of various colors, such as yellow and another green, instead of white.

In a case where a pixel color other than W is added, as with a case where the pixel color to be added is W, the BL control parameter calculating section **86** calculates a BL control parameter from the perspective that, for example, an appropriately bright display is obtained.

(User Entering Section)

Next, a user entering section **92** will be described below. A user of the display device **10** enters, via the user entering section **92**, a desired luminance of a displayed image and a desired luminance of the backlight unit **30**.

The user entering section **92** (i) calculates a BL control parameter in accordance with the entering by the user and (ii) supplies the BL control parameter to the BL luminance control signal generating block **44**.

Note that a location where the user entering section **92** is provided is not limited to a specific location. The user entering section **92** can be provided, for example, in the display device **10** or independently of the display device **10**.

(BL Luminance Control Signal Generating Block) The BL luminance control signal generating block **44** will be described below. The BL luminance control signal generating block **44** (i) generates a BL luminance control signal (luminance control signal) and (ii) supplies the BL luminance control signal to the BL unit controlling section **32**.

According to Embodiment 1, the BL luminance control signal generating block **44** is provided in the timing control section **40**. Note, however, that a location where the BL luminance control signal generating block **44** is provided is not limited to a specific location. For example, the BL luminance control signal generating block **44** can be provided in the display device **10**, independently of the timing control section **40**.

The BL luminance control signal generating block **44** receives a plurality of BL control parameters, as has been described. That is, the BL luminance control signal generating block **44** receives (i) a CABC-based BL control parameter from the BL control parameter calculating section **58** of the CABC block **50**, (ii) a LABC-based BL control parameter from the BL control parameter calculating section **74** of the LABC block **70**, (iii) an RGBW-based BL control parameter from the BL control parameter calculating section **86** of the RGBW block **80** and (iv) a user-based BL control parameter from the user entering section **92**.

Note that the kind and the number of BL control parameters to be supplied to the BL luminance control signal generating block **44** are not particularly limited, provided that the BL luminance control signal generating block **44** receives two or more BL control parameters.

(Generation of BL Luminance Control Signal)

The following description will discuss how the BL luminance control signals are generated.

According to the BL luminance control signal generating block **44** of Embodiment 1, (i) a plurality of inputted BL control parameters are subjected to a calculation process in advance so that a parameter is obtained and (ii) a BL luminance control signal is generated on the basis of the parameter.

Conventionally, in a case where a plurality of factors were needed to determine a luminance of a backlight unit, a signal for actually controlling the luminance of the backlight unit was generated by combining a plurality of BL luminance control signals, for example, by combining PWM (Pulse Width Modulation) signals (as early described).

On the other hand, according to the BL luminance control signal generating block **44** of Embodiment 1, no process is carried out with respect to a plurality of control signals, but (i) a plurality of control parameters are processed so as to calculate a parameter and then (ii) a control signal is generated on the basis of the parameter. This will be described below with reference to drawings.

FIG. **2** is a block diagram schematically illustrating how luminance is controlled in the display device **10** of Embodiment 1.

FIG. **2** illustrates, for ease of description, a case where only two different parameters (parameters regarding the luminance of the backlight) are supplied to the BL luminance control signal generating block **44**.

As illustrated in FIG. **2**, the BL luminance control signal generating block **44** is connected to a BL control block A **45** and a BL control block B **46**. The BL control block A **45** and the BL control block B **46** correspond to, for example, the LABC block **70** and the CABC block **50**, respectively.

The BL control block A **45** and the BL control block B **46** supply, to the BL luminance control signal generating block **44**, not BL luminance control signals but respective parameters (a parameter A and a parameter B) regarding control of the luminance of the backlight unit **30**.

In the BL luminance control signal generating block **44**, (i) the parameters A and B are subjected to a calculation process and then (ii) a BL luminance control signal is generated on the basis of a result of the calculation process.

(Calculation Example 1 of Parameter)

Examples of how to calculate parameters will be described below with reference to FIG. **3**. FIG. **3** is a view illustrating an example of how to calculate parameters in Embodiment 1.

Calculation Example 1 illustrates an example case where (i) a parameter (BL control parameter) to be supplied to the BL luminance control signal generating block **44** is a duty ratio and (ii) a BL luminance control signal to be outputted from the BL luminance control signal generating block **44** is a PWM signal (see FIG. **3**).

Furthermore, in Calculation Example 1, a calculation process is a multiplication.

In Calculation Example 1, the parameter A is a duty ratio of 70/100, and the parameter B is a duty ratio of 30/100 (see FIG. **3**).

The two different duty ratios are multiplied by each other, so that a duty ratio of 21/100 is obtained. On the basis of the duty ratio of 21/100, a PWM signal is generated as a BL luminance control signal. Specifically, the BL luminance control signal generating block **44** (i) generates a PWM signal having a duty of 21% and (ii) supplies the PWM signal to the BL unit controlling section **32**.

This allows the luminance of the backlight unit **30** to be properly controlled, without causing, for example, (i) an unintentional elimination of a signal and (ii) an unintentional turn-off of the backlight unit **30**, each of which will occur in a case where two different PWM signals are superimposed on each other.

(Calculation Example 2 of Parameter)

Another example of how to calculate parameters will be described below with reference to FIG. **4**. FIG. **4** is a view illustrating the another example of how to calculate parameters in Embodiment 1.

Calculation Example 2 (see FIG. **4**) is different from Calculation Example 1 (see FIG. **3**) in that a parameter (BL control parameter) to be supplied to the BL luminance control signal generating block **44** is a luminance level in Calculation Example 2, whereas the parameter is a duty ratio in Calculation Example 1.

Specifically, according to Calculation Example 2, the parameter A is a luminance level of 12/16, and the parameter B is a luminance level of 4/8 (see FIG. **4**).

The two different luminance levels are multiplied by each other, so that a luminance level of 6/16 is obtained. On the basis of the luminance level of 6/16, a PWM signal is generated as a BL luminance control signal.

Note that, in a case of Calculation Example 2, a correlation table, which shows how a luminance level and a duty ratio of a PWM signal are correlated with each other, is prepared in advance. FIG. **5** illustrates an example of the correlation table.

In Calculation Example 2, the luminance level of 6/16 is obtained, and then a duty ratio of 55 is obtained with reference to the correlation table (see FIG. **5**). The BL luminance control signal generating block **44** (i) generates, as a BL luminance control signal, a PWM signal having a duty ratio of 55% and (ii) supplies the PWM signal to the BL unit controlling section **32**.

This prevents an occurrence of a problem which will be caused in a case where two PWM signals are superimposed on each other, as with a case of Calculation Example 1. It is therefore possible to properly control the luminance of the backlight unit **30**.

Note that Embodiment 1 has described (i) an example case where a BL control parameter is a duty ratio and (ii) an example case where the BL control parameter is a luminance level. Note, however, that kinds of the BL control parameter are not limited to the duty ratio and the luminance level.

Note also that Embodiment 1 has described an example case where a BL luminance control signal is a PWM signal. Note, however, that kinds of the BL luminance control signal are not limited to the PWM signal. The BL luminance control signal can be, for example, an analog voltage signal or digital data.

In a case where the BL luminance control signal is the digital data, the BL unit controlling section **32** (i) receives the digital data via an I/F such as an SPI or an I2C and (ii) controls the luminance of the backlight unit **30** in accordance with the digital data.

Note also that Embodiment 1 has described an example case where the BL luminance control signal generating block **44** carried out a multiplication as a calculation process. Note, however, that the calculation process to be made is not limited to the multiplication. The calculation process can be, for example, addition, averaging, or utilization of a combination table.

Note here that what is meant by "utilization of a combination table" is that a BL luminance control signal is generated on the basis of a table, prepared in advance, in which PWM duty ratios are correlated with respective combinations of parameters, for example, a PWM duty ratio is set to 25% in a case where a parameter A equals to 0 (zero) and a parameter B equals to 1.

Note also that the calculation process is not limited to a single calculation. Two or more different calculations can be made in combination.

Examples of the two or more different calculations include (i) a calculation of an arithmetic mean value, (ii) a calculation of a weighted average efficiency (an average value of weighted parameters), (iii) extraction of a maximum value, (iv) extraction of a minimum value, and (v) calculation of a median.

Some of (i) the calculation process examples and (ii) a process based on the table can be combined. For example, in a case where there are three different parameters (parameters A, B and C), the following calculation process can be made. That is, an average value (arithmetic mean value) of the parameter A and the parameter B is calculated, and then the average value is multiplied by the parameter C.

(Calculation Example 3 of Parameter)

A further example of how to calculate parameters will be described below with reference to FIGS. **6** and **7**. FIG. **6** is a block diagram schematically illustrating another luminance control of Embodiment 1. FIG. **7** is a view illustrating a further example of how to calculate parameters.

Calculation Example 3 is different from Calculation Example 1 in the number of parameters. Specifically, according to Calculation Example 3, a BL luminance control signal generating block **44** is connected to three different BL control blocks (i.e., a BL control block A **45**, a BL control block B **46**, and a BL control block C **47**) (see FIG. **6**), whereas, according to Calculation Example 1, the BL luminance control signal generating block **44** is connected to the two BL control blocks (i.e., the BL control block A **45** and the BL control block B **46**) (see FIG. **2**). In other words, according to a display device **10** illustrated in FIG. **6**, the BL luminance control signal generating block **44** is connected to the BL control block C **47**, in addition to the BL control block A **45** and the BL control block B **46**. The BL control block C **47** corresponds to, for example, the RGBW block **80**.

As illustrated in FIG. **6**, the BL luminance control signal generating block **44** receives a parameter C from the BL control block C **47**, in addition to a parameter A from the BL control block A **45** and a parameter B from the BL control block B **46**.

In the BL luminance control signal generating block **44**, (i) the parameters A, B and C are subjected to a calculation process and (ii) a BL luminance control signal is generated on the basis of a result of the calculation process.

Calculation Example 3 will be described below with reference to FIG. **7**.

As early described, Calculation Example 3 is different from Calculation Example 1 in the number of parameters to be taken into consideration.

In Calculation Example 3, the parameter A is a duty ratio of 80/100, the parameter B is a duty ratio of 60/100, and the parameter C is a duty ratio of 50/100 (see FIG. **7**).

The three different duty ratios are multiplied by one another, so that a duty ratio of 24/100 is obtained. On the basis of the duty ratio of 24/100, a PWM signal is generated as a BL luminance control signal. Specifically, the BL luminance control signal generating block **44** (i) generates a PWM signal having a duty ratio of 24% and (ii) supplies the PWM signal to a BL unit controlling section **32**.

This makes it possible to properly control the luminance of the backlight unit **30**.

Even in a case where the number of parameters is increased, it is thus possible to make a calculation process in the same manner as that made in a case where the number of parameters is two. That is, even in a case where the BL luminance control signal generating block **44** receives, for example, four different BL control parameters (see FIG. **1**), it is possible to make a calculation process with respect to the four different BL control parameters in the same manner as that made in Calculation Example 3.

Note that, even in a case where the kind of parameters is a parameter, such as a luminance level, other than a duty ratio, it is possible to similarly make a calculation process.

Embodiment 2

The following description will discuss a display device **10** in accordance with Embodiment 2 of the present invention with reference to FIG. **8**. FIG. **8** is a block diagram schematically illustrating how the display device **10** of Embodiment 2 is configured.

Note that, for convenience, identical reference numerals are given to members having respective functions identical to those illustrated in the drawings of Embodiment 1, and descriptions of the members are omitted in Embodiment 2.

The display device **10** of Embodiment 2 is different from that of Embodiment 1 in a location where an RGBW block **80** is provided. Specifically, the RGBW block **80** of Embodiment 2 is provided in a timing control section **40**, whereas the RGBW block **80** of Embodiment 1 is provided in the signal line driving circuit **24**.

Since the RGBW block **80** is provided in the timing control section **40**, the display device **10** of Embodiment 2 has the following advantage.

Specifically, an RGBW image processing circuit to be provided in the RGBW block **80** is in relatively large scale. It is therefore relatively easier to provide the RGBW image processing circuit (i) in the timing control section **40** (an LCD controller IC etc.) to be provided on a set-side on which the display device **10** is not provided than (ii) in a circuit (an IC etc.), like a signal line driving circuit **24** (an LCD driver IC etc.), whose size is strictly restricted because the circuit is provided in a frame region of a display panel **20** (a liquid crystal display panel etc.).

Since the RGBW block **80** is thus provided in the timing control section **40**, it is possible to downsize the signal line driving circuit **24**. This causes the frame region to be narrowed. It is therefore possible to improve design of the display panel **20**.

Embodiment 3

The following description will discuss a display device **10** of Embodiment 3 of the present invention with reference to FIG. **8**. FIG. **9** is a block diagram schematically illustrating how the display device **10** of Embodiment 3 is configured.

Note that, for convenience, identical reference numerals are given to members having respective functions identical to those illustrated in the drawings of Embodiments 1 and 2, and descriptions of the members are omitted in Embodiment 3.

The display device **10** of Embodiment 3 is different from that of Embodiment 1 in a location where a LABC block **70** is provided. Specifically, the LABC block **70** of Embodiment 3 is provided independently of the display device **10**, whereas the LABC block **70** of Embodiment 1 is provided in the display device **10**.

Since the LABC block **70** is provided independently of the display device **10**, the display device **10** of Embodiment 3 has the following advantage.

Generally, an illuminance detecting section **94** (an illuminance sensor etc.) is often provided on a substrate on a set-side on which the image display device is not provided, instead of being provided in an image display device. Because of this, an LABC block **70** is often realized by a CPU, an LSI, or the like on the set-side, not by the image display device.

By providing the LABC block **70** not in the display device **10** but independently of the display device **10**, it is possible to effectively utilize a LABC function provided on the set-side. This allows (i) a structure of the LABC block **70** to be simplified, (ii) the LABC block **70** to be produced easily, and (iii) a cost to be suppressed.

(Display Panel)

The configuration of the display panel **20** of each of Embodiments 1 through 3 is not limited to a specific configuration.

For example, in a case where the display panel **20** is employed as a liquid crystal display panel, the display device **10** can be employed as a liquid crystal display device.

(Backlight Unit)

Each of Embodiments 1 through 3 has described a configuration in which the backlight unit **30** and the BL unit controlling section **32** are provided in the display device **10**. The present invention is, however, not limited to such a configuration. Alternatively, for example, the backlight unit **30** and the BL unit controlling section **32** can be provided independently of the display device **10**.

(Timing Control Section)

Each of Embodiments 1 through 3 has described a configuration in which the timing control section **40** is provided in the display device **10**. The present invention is, however, not limited to such a configuration. For example, the timing control section **40** excluding the BL luminance control signal generating block **44** can be provided independently of the display device **10**, while the BL luminance control signal generating block **44** is still provided in the display device **10**.

The present invention is not limited to the description of the embodiments above, and can therefore be modified by a skilled person in the art within the scope of the claims. Namely, an embodiment derived from a proper combination of technical means disclosed in different embodiments is encompassed in the technical scope of the present invention.

The display device of the present invention is characterized in that the signal generating section is connected to a backlight unit via a backlight unit controlling section, the luminance control signal is supplied from the signal generating section to the backlight unit controlling section, and the backlight unit controlling section controls a luminance of the backlight unit in accordance with the luminance control signal.

The display device of the present invention is characterized in that the backlight unit controlling section and the backlight unit are provided in the display device.

According to the configuration, the backlight unit controlling section is provided in the display device. It can therefore be configured such that the backlight unit controlling section easily controls the luminance of the backlight in accordance with the luminance control signal generated by the signal generating section.

The display device of the present invention can be configured so that each of the plurality of parameters is a duty ratio of a PWM signal.

The display device of the present invention can be configured so that each of the plurality of parameters is a luminance level of the backlight.

The display device of the present invention is characterized in that the signal generating section generates the luminance control signal by multiplying the plurality of parameters by each other.

A method, of the present invention, of generating a luminance control signal is characterized in that the calculation process is multiplication.

According the configuration or the method, the calculation process is multiplication. It is therefore possible to make the calculation process with a simple circuit configuration. Further, by multiplying parameters by each other, it is possible to easily generate a luminance control signal on which luminance control factors are suitably reflected.

The display device of the present invention is characterized in that the luminance control signal is a PWM signal.

In a case where a control signal is a PWM signal, it is possible to easily employ a typical control circuit for controlling a backlight. This makes it easy to attain (i) simplification of a structure of the circuit and (ii) reduction in cost.

The display device of the present invention is characterized in that the plurality of parameters are supplied to the signal generating section from at least one of an image signal converting section, an external light illuminance processing section, an image information processing section, and a user entering section.

According to the configuration, the luminance of the backlight is determined on the basis of various parameters regarding the luminance of the backlight.

It is therefore possible to determine a suitable luminance of the backlight from various viewpoints such as (i) an environment where the display device is used and (ii) what is displayed in the display device.

The display device of the present invention is characterized in that the display device is a liquid crystal display device including a liquid crystal display panel as a display panel.

The method is characterized in that the calculation process is at least one of (i) calculation of an arithmetic mean value, (ii) calculation of a weighted average efficiency, (iii) extraction of a maximum value, (iv) extraction of a minimum value and (v) calculation of a median.

The method is characterized in that the calculation process is a process which is carried out based on a combination table in which luminance control signals are set in advance for respective combinations of the plurality of parameters.

INDUSTRIAL APPLICABILITY

The present invention is suitably applicable to a display device which controls a luminance of a backlight unit on the basis of a plurality of factors.

REFERENCE SIGNS LIST

10: display device
20: display panel
22: scan line driving circuit
24: signal line driving circuit
30: backlight unit
32: BL unit controlling section
40: timing control section
42: timing generation block
44: BL luminance control signal generating block
45: BL control block A
46: BL control block B
47: BL control block C
50: CABC block
52: image analyzing section
54: gray scale converting section
56: gray scale characteristic determining section
58: BL control parameter calculating section
70: LABC block
72: filter section
74: BL control parameter calculating section
80: RGBW block
82: RGB data converting section
84: expansion coefficient calculating section
86: BL control parameter calculating section
90: system-side control section
92: user entering section
94: illuminance detecting section
100: display device
110: BL control block A
120: BL control block B
130: control signal synthesizing section
140: BL unit controlling section
150: backlight unit

The invention claimed is:

1. A display device, comprising:

a signal generating controller that generates a luminance control signal to control a luminance of a backlight, wherein

the signal generating controller (i) receives a plurality of parameters regarding the luminance of the backlight, (ii) carries out a calculation process with respect to the plurality of parameters, and (iii) generates the luminance control signal on the basis of a result of the calculation process,

the plurality of parameters include at least three parameters including at least (i) a parameter that is calculated when an input image is converted to an output image via gray scale conversion, and (ii) a parameter that is calculated when RGB data of the output image is converted into RGBW data, and

the calculation process includes a combination of at least two different calculations.

2. The display device as set forth in claim **1**, wherein:

the signal generating controller is connected to the backlight via a backlight controller,

the luminance control signal is supplied from the signal generating controller to the backlight controller, and

the backlight controller is configured to control the luminance of the backlight in accordance with the luminance control signal.

3. A display device as set forth in claim **2**, wherein:

the backlight controller and the backlight are provided in said display device.

4. The display device as set forth in claim **1**, wherein:

the signal generating controller generates the luminance control signal by multiplying the plurality of parameters by each other.

5. The display device as set forth in claim **1**, wherein:

the luminance control signal is a PWM signal.

6. The display device as set forth in claim **1**, wherein:

the plurality of parameters are supplied to the signal generating controller from at least one of an image signal converting circuit, an external light illuminance processor, an image information processor, and a user entering input.

7. A display device as set forth in claim **1**, wherein the display device is a liquid crystal display device including a liquid crystal display panel as a display panel.

8. A method of generating a luminance control signal for controlling a luminance of a backlight,

the method comprising the steps of:

(i) carrying out a calculation process in advance with respect to a plurality of parameters regarding the luminance; and

(ii) generating the luminance control signal on the basis of a result of the calculation process; wherein

the plurality of parameters include at least three parameters including at least (i) a parameter that is calculated when an input image is converted to an output image via gray scale conversion, and (ii) a parameter that is calculated when RGB data of the output image is converted into RGBW data, and

the calculation process includes a combination of at least two different calculations.

9. The method as set forth in claim **8**, wherein:

the calculation process is multiplication.

10. The method as set forth in claim **8**, wherein:

the calculation process is at least one of (i) calculation of an arithmetic mean value, (ii) calculation of a weighted average efficiency, (iii) extraction of a maximum value, (iv) extraction of a minimum value, and (v) calculation of a median.

11. The method as set forth in claim **8**, wherein:

the calculation process is a process which is carried out based on a combination table in which luminance control signals are set in advance for respective combinations of the plurality of parameters.

* * * * *